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मानक

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“Step Out From the Old to the New”

IS 11141 (1984): Code of safety for acrylonitrile [CHD 8: Occupational Safety, Health and Chemical Hazards]



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Bhartrhari—Nitiśatakam

“Knowledge is such a treasure which cannot be stolen”

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REAFFIRMED

IS : 11141 - 1984

Indian Standard
CODE OF SAFETY FOR ACRYLONITRILE

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MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

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April 1985

Indian Standard

CODE OF SAFETY FOR ACRYLONITRILE

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**AMENDMENT NO. 1 DECEMBER 2006
TO
IS 11141 : 1984 CODE OF SAFETY FOR
ACRYLONITRILE**

(Page 5, clause 4.1.1) — Substitute the following for the existing text:

‘Confirmed animal carcinogen with unknown relevance to humans. TLV –
TWA: 2 ppm.’

(CHD 8)

Reprography Unit, BIS, New Delhi, India

Indian Standard

CODE OF SAFETY FOR ACRYLONITRILE

0. FOREWORD

0.1 This Indian Standard was adopted by the Indian Standards Institution on 30 April 1984, after the draft finalized by the Chemical Hazards Sectional Committee, had been approved by the Chemical Division Council.

0.2 Acrylonitrile is used in the manufacture of synthetic fibres, acrylostyrene plastics, acrylonitrile-butadiene-styrene plastics, nitrile rubbers, chemicals and adhesives, and also as a pesticide.

0.3 Acrylonitrile is a hazardous material due to its toxicity, flammability in air and potential polymerisation capability; yet it can be produced and handled with safety, provided precautions are taken and observed.

0.4 In the preparation of this code, considerable assistance has been derived from the following publications:

- a) Codes of practice for chemicals with major hazards—Acrylonitrile; Chemical Industry Safety & Health Council of the Chemical Industries Association Limited, London; 1978.
- b) Marshall Sittig—Hazardous and toxic effects of industrial chemicals; 1979; Noyes Data Corporation, New Jersey, U.S.A.

1. SCOPE

1.1 This standard covers properties of acrylonitrile, the nature of hazards associated with it and essential information on storage, handling, packing, labelling, disposal of waste, cleaning and repair of containers, selection and training of personnel, personnel protective equipment and first aid.

2. TERMINOLOGY

2.1 For the purpose of this standard, the definitions given in IS : 4155-1966* shall apply.

*Glossary of terms relating to chemical and radiation hazards and hazardous chemicals.

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3. PROPERTIES

3.1 General Information — Acrylonitrile is a colourless, liquid having mild pungent odour. It is inflammable.

3.1.1 Common Names — Acrylonitrile, fumigrain, ventox.

3.1.2 Chemical Names — Vinyl cyanide, cyanoethylene, propene nitrile, acrylon, carbacryl.

3.1.3 Empirical Formula — C_3H_3N .

3.1.4 Molecular Formula — $CH_2=CH-CN$.

3.1.5 Molecular Weight — 53.1.

3.2 Physical Properties

3.2.1 Description, Colour, Odour, Physical State — Acrylonitrile is a colourless mobile liquid with a faint acrid odour. The technical grade may have a slight yellow tinge. It is both flammable and explosive.

3.2.2 Melting Point/Freezing Point — Minus 82°C to minus 83°C.

3.2.3 Boiling Point — 77.3°C.

3.2.4 Specific Gravity — 0.8 at 20°C.

3.2.5 Viscosity — 0.34 cP at 20°C.

3.2.6 Vapour Pressure — 26.6 kP at 40°C and 11.4 kP at 20°C.

3.2.7 Heat of Freezing — Information not available.

3.2.8 Heat of Vaporisation — 617 kJ/kg.

3.2.9 Miscibility/Solubility in Common Solvents — At 20°C acrylonitrile 7.35 percent by mass is soluble in most of the organic solvents.

3.2.10 Refractive Index — 1.388 8 at 20°C.

3.2.11 Vapour Density — 1.93.

3.3 Chemical Properties

3.3.1 Affinity for Other Chemicals — Contact with strong acids like sulphuric acid and nitric acid may lead to violent reactions since these acids will neutralize the inhibitor present in the acrylonitrile and leave the nitrile unstabilized. It undergoes polymerization with strong alkalis which is exothermic and hazardous. Peroxide and other oxidising agents also initiate polymerization.

3.3.2 Stability at High Temperature — Auto-ignites at 480°C.

3.3.3 Acrylonitrile is sensitive to light and even when inhibited, it will polymerize at above 200°C with rapid increase of pressure. It should never be stored uninhibited and at high temperature. It polymerises with light.

3.3.4 Flammability — Highly flammable.

3.4 Fire and Explosion Hazard Properties

3.4.1 Flash Point — -1°C (closed cup).
21.1°C for 2 percent aqueous solution
12.2°C for 3 percent aqueous solution
8.88°C for 5 percent aqueous solution

3.4.2 Ignition Temperature — 480°C.

3.4.3 Explosive Limits in Air at 25°C — 3 percent by volume (LEL)
17 percent by volume (UEL)

3.5 Corrosion Properties

3.5.1 Non-corrosive to metals. The product may produce welt on the skin.

3.5.2 Corrosive to copper and copper bearing alloys.

4. HEALTH EFFECTS AND TOXICITY INFORMATION

4.1 General

4.1.1 Suspected Carcinogen — No threshold limit value (TLV) available.

4.1.2 Exposure Concentration, Duration and Health Effects — Contact produces severe burns, penetrates into skin and causes dermatitis later. Inhalation causes irritation of mucous membrane. Long term exposure of acrylonitrile has been shown to cause cancer in laboratory animals and has been associated with higher incidence of cancer in humans. In long term exposures acrylonitrile is a potential carcinogenic substance on prolonged exposure.

4.2 Routes of Entry — Inhalation and percutaneous absorption. It may be absorbed from contaminated rubber or leather.

4.3 Health Effects — Early symptoms to exposure include irritation of eyes, vomiting, sneezing, headache, weakness and abdominal pain. The appearance of such symptoms need immediate termination of exposure. Continued contact of liquid or vapours can cause dermatitis. The toxic effect on human body appears to result from gradual liberation of cyanide

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ions and resembles poisoning by hydrocyanic acid. Acrylonitrile can be easily absorbed by leather shoes from spillage on floor and can cause blisters on foot, resembling second degree burns. Health effects resemble poisoning by hydrocyanic acid (HCN). Symptoms will probably be slower to develop than in the case of HCN poisoning. But by the time symptoms appear, the victim would have had higher acrylonitrile level in blood. Thus the treatment required will have to be more efficient for cases of acrylonitrile poisoning.

4.3.1 Eyes — Liquid splashed in eye causes immediate pain and inflammation, should be flushed without delay by washing the eye continuously with water.

4.3.2 Skin — Skin contact with liquid, wetted clothing or shoe leather which has absorbed acrylonitrile may cause dermatitis manifested by blistering of contact area unless the skin is cleared immediately after contact.

4.3.3 Systemic — Acrylonitrile exposure may produce nausea, vomiting, headache, sneezing, weakness and light-headedness. Exposure to high concentrations may produce profound weakness, asphyxia and death. Toxic effect is exerted through inhalation of vapour, ingestion of liquid and absorption through intact skin contacting the liquid. The hazard of intoxication through these routes decrease in the order given. Because of its high vapour pressure at room temperature, the hazard of intoxication through vapour inhalation is very great.

4.3.3.1 Organs or systems affected — Skin, eyes, mucous membrane. Cancer of the liver, lungs or stomach.

5. STORAGE, HANDLING AND TRANSPORT

5.1 Storage — Due to its flammability, acrylonitrile should not be stored close to other materials that present a fire or explosion hazard. Due to its ability to polymerise rapidly under certain condition, the following points should be observed:

- a) Acrylonitrile held in bulk storage should be stabilised, for example:
 - i) by the methyl ether of hydroquinone (MEHQ) (para methoxyphenol) (ca. 40 ppm) when the acrylonitrile contains dissolved oxygen.
 - ii) by ammonia (ca. 100 ppm). As ammonia combines with acrylonitrile to form stabilising compounds, it will necessarily decrease in concentration. The best method, therefore, of determining stabiliser concentration is by titration value.
 - iii) by water, which at 0.2 percent m/m confers some stabilisation.
- b) There must be no possibility of introducing strong alkali or peroxides into a storage vessel or into a bund enclosure.

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5.1.1 The material of construction of equipment and containers shall be as follows:

<i>Equipment</i>	<i>Material of construction</i>
All equipment	Carbon steel, stainless steel and aluminium (copper or copper alloy <i>should not</i> be used)
Storage tanks	Carbon steel tank plate confirming to IS : 1079-1973*
Drums	Mild steel drums
Tankers	Carbon steel or aluminium
Valves	Globe or gate type, all iron
Pumps	All steel (<i>no</i> copper and copper alloy); impeller body ordinary carbon steel or cast iron
Pipelines	Suitable material
Flanges	Carbon steel
Mechanical seal	Copper or copper alloy (double seal preferred to avoid leakages)

Strong acids like sulphuric acid and nitric acid should be stored away from acrylonitrile.

A high level alarm shall be provided in addition to the normal level indicator to avoid inadvertent overfilling. Consideration should be given to install a high level cut-out on the charge pump. Tank filling lines should be bottom entry, but, if top entry, they should extend to within 75 mm of the base of the tank and be drilled near the tank top to prevent syphoning.

5.1.2 All rooms in which acrylonitrile is stored should be fire resistant and be provided with adequate ventilation. Venting may be to atmosphere through a flame arrestor but this method is dependent on the siting of the tank because an explosive mixture can be present in the vapour space [3 to 17 percent acrylonitrile (*see 3.4.3*)]. Such vents should be installed at least 3 m above any working level. Blanketing with nitrogen is an alternative because it avoids possible explosive vapour mixtures. To avoid atmospheric pollution, such nitrogen purges should either be vented to a vent scrubber and the scrubber liquor returned to process, or be vented back to process by balance line.

5.1.3 All above-ground stock tanks should be surrounded by a bund. Where tanks can be banded individually, the bund should have sufficient capacity to contain the tank contents above the bund wall level, plus 10 percent. Where more than one tank is surrounded by a single bund the

*Specification for hot rolled carbon steel sheet and strip (*third revision*).

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net capacity of the bund, after making allowances for the volume occupied by the other tanks, should be sufficient to contain the contents above bund level of the largest tank, plus 10 percent. The ground within the bund should be impervious to acrylonitrile and so sloped that minor spillages will not remain beneath or around vessels. It is recommended that bund walls should be no higher than 1.5 m. Facilities for emptying the bund must be available. If a self-draining bund is used, the drain valve should be closed except when draining is in progress. Samples should not be taken during hailstorms and lightnings, and periodical checking of inhibitor in the tank should be done.

5.1.4 All electrical wiring, motors and other equipment installed or used where acrylonitrile is stored should be explosion proof. All storage tanks should be fitted with a vent pipe/breathers. Although at normal pumping rates of 3 m/sec acrylonitrile should not generate electrostatic charges in pipelines, all items of plant handling acrylonitrile shall be earthed in an approved manner against static discharges. Structural steelwork shall be effectively earthed and plant equipment bonded to the structural steelwork.

5.1.5 Storage area should be away from all sources of open flame, heaters, furnaces and welding or other flame or spark producing equipment, 'No Smoking' signs should be put in the area. All storage tanks should be grounded. Storage tanks should be provided with cooling water spray system.

5.2 Handling and Transfer

5.2.1 Drum Storage and Handling — Acrylonitrile is transported in drums also made of mild steel. The following points should be considered while handling and storage of acrylonitrile drums:

- a) The drums should be opened carefully to prevent damage. They should not be dropped or bumped.
- b) Handling operation should be performed in areas which are properly ventilated and free from source of ignition. Equipment used in storage, transfer and processing, such as pipes and valves, should be free from contamination.
- c) Before drums are opened, they should be grounded to discharge accumulated static electricity.
- d) Drums should be stored on end with the bangs up. Do not stack them too high.
- e) Use only non-sparking tools, wrenches to remove the plug.
- f) While handling drums, use personal protective equipment.
- g) Drums should be stored in cool place away from sunlight.
- h) Do not use air pressure to unload the drums.

- j) If pumps are used for unloading, they should be provided with valves on both suction and discharge side. If pumps are used to deliver acrylonitrile to storage tanks they should be provided with check valves to prevent the back flow of liquid from tanks to pumps.
- k) Used acrylonitrile drums may be cleaned by flushing with water at least twice and steaming using low pressure steam.
- m) All tools used in the unloading operation should be free from oil, grit and dirt.

5.2.2 Spills and leakages of acrylonitrile should be cleaned up by employees provided with adequate personal protective equipment. Contaminated clothing should be removed immediately and washed. In case of heavy spill or leak, shut off any ignition source, keep people away, keep up wind and shut off the leak if it does not involve personal risk. If necessary to enter spill area, wear self-contained breathing apparatus and full protective clothing including rubber boots. Dike large spills and remove by pumping into a salvage tank. Use water spray to knock down vapour. If removal is impossible or for small spills flush area with water spray. Run off to sewer or drains may create explosion hazard. Notify authorities.

5.3 Transport

5.3.1 Protective equipment consisting of neoprene or PVC gloves, boots and suit, together with compressed air-breathing apparatus with full face mask should be worn when connecting or disconnecting pipelines which have contained acrylonitrile but have not been gas-freed.

A safety shower should be in the near vicinity of any loading or unloading area.

Loading and unloading operations shall not be undertaken by an operator on his own.

Adequate ventilation must be provided where there is transfer into or from drums.

Drum filling machines should be provided with an automatic cut-off allowing ullage for thermal expansion.

When a load of drums is received in an enclosed truck, thorough ventilation should take place before it is entered. Each consignment should be inspected for leaking drums.

Drums should not be emptied by means of air pressure.

Drums should be earth-bonded before transfer of liquid.

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Acrylonitrile is usually transported through pipelines, tankers and drums of approved design and construction as per instructions laid down. In-plant transfers are usually done through insulated pipelines.

To remove residual acrylonitrile after discharging, drums should be thoroughly steamed or washed out by filling them with water at least twice and completely draining them each time. As an alternative, decontamination by chemical cleaning may be used, that is by hypochlorite or ammonia solution. There is a need for control, possibly by exhaust ventilation to an appropriate place, of the toxic inhalation risk which might arise from displaced vapour and steam.

5.3.2 Acrylonitrile Road Tankers — Acrylonitrile is transported in bulk quantities in tankers. Tankers should be constructed of steel. All containers used to transport, store or handle acrylonitrile should be thoroughly cleaned, because contaminants may catalyse polymerisation of acrylonitrile or cause rapid decomposition. Proper warning labels and hazard signs and fire fighting modus should be marked on the tanker vehicles. Acrylonitrile should never be transported uninhibited.

5.3.3 Safety while Unloading Tankers — Because of the highly flammable and toxic properties of acrylonitrile, the following preliminary precautions should be observed:

- a) Unloading operation should be carried out by trained personnel and under adequate supervision.
- b) Choose well ventilated location for the unloading operation and ban the use of open light and flames in the area. Use only clean non-sparking tools.
- c) Before any connection or contact is made between a car and the unloading line, or any other unloading equipment, the tank car should be grounded and bonded, the unloading line and the pumping equipment should also be grounded in order to discharge static electricity.
- d) The contents of the tank car should be discharged only in the day time or when adequate lighting is provided.
- e) *Never* use air pressure to unload acrylonitrile tanker. If nitrogen is used, its pressure should not exceed 2 kg/cm² provided tanker is designed and tested to withstand this pressure.
- f) *Naked flame should not be allowed* in the area.
- g) *Smoking should be strictly prohibited* in the area.
- h) All tools used in the unloading operation should be of the non-sparking type and should be kept free from oil, dirt and grease.

- j) Fire fighting equipment should be immediately available to the unloading area personnel and they should be familiar with its proper use. Dry chemical extinguishers are recommended. At least one man should be in constant attendance during the unloading.
- k) Personal protective equipment like helmet, face shield, spectacle goggles, PVC hand gloves and safety shoes should be used while unloading. Respiratory equipment may also be used.
- m) The engines of any other vehicles should be stopped if within 15 m of transfer operations.

If the tanker is not fitted with a dip filling tube, a loading arm extension should be used which extends to the bottom of the tank to avoid excessive fall and to minimise the generation of static electricity.

Before any connections are made for transfer, adequate precautions shall be taken to prevent inadvertent movement of the tanker.

Tanker unloading should preferably be done by a hand pump. If pressurising is used, even for pump priming, an inert gas must be used (preferably nitrogen).

Means shall be provided to prevent overfilling of the tanker.

6. FIRE PREVENTION AND FIRE FIGHTING

6.1 Types of Extinguishing Agents and Equipments Which can be Used — Dry chemical powder extinguishers, foam extinguishers, foam guns, monitors, hoses, keys, etc, foam concentrate, emulsifying agent and applicator carbon dioxide type.

7. SPILLAGE, LEAKAGE AND SCOPE OF MATERIAL

7.1 Burning Acrylonitrile — Burning acrylonitrile will release cyanide gases particularly where the air supply is limited. It burns with a dense black smoke. Fires should be fought from the up-wind direction if possible and areas down-wind should be monitored. Fire fighters should be equipped with self-contained breathing apparatus and correct protective clothing.

7.2 Fire Hazard — The vapour is invisible, heavier than air and spreads along ground. It can form explosive mixture with air particularly in empty uncleaned receptacles. Heating will cause pressure rise, and severe risk of bursting and explosion. Acrylonitrile if co-inhibited, may form polymers in vents or flame arrestors of storage tanks, resulting in stopping of vents.

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7.3 Toxic Hazard — Acrylonitrile is toxic by ingestion, by inhalation of the vapour or by absorption of the liquid through the skin. Symptoms of acrylonitrile poisoning by whatever route of entry, are, in order of onset: irritation of eyes and nose, limb weakness, laboured breathing, dizziness and impaired judgement, cyanosis and neusea, collapse, irregular breathing, convulsions. The pulse becomes rapid whilst the eyes and throat may become suffused. When the symptoms include collapse, irregular breathing, or convulsions, cardiac arrest may occur without warning. Some patients may display hysteria or even violence. Liquid on exposed skin can be readily absorbed and will cause irritation and blistering unless washed off at once. The vapour affects the eyes mildly, but the liquid in the eye will result in severe irritation, and permanent eye damage may result.

7.4 Safety Showers — Safety showers with freeze protection should be provided at appropriate locations. Any affected areas of skin should be washed immediately, eyes flushed with water and medical attention obtained.

Contaminated clothing and footwear should be removed immediately.

Contaminated clothing should be exposed to air and laundered before re-use. Footwear and other leather articles must be destroyed, since acrylonitrile is easily absorbed by leather.

Any protective clothing that is worn, should be washed immediately after exposure.

In all cases of severe exposure or when this is suspected, medical attention should be obtained immediately.

7.5 Double Safety in Plant — The plant should be designed for complete containment of liquid acrylonitrile.

A double safeguard philosophy should be adopted wherever possible to minimise the escape of acrylonitrile in the event of equipment failure and/or human failure, which may occur in inspection, maintenance or in normal operation.

The area classification of a plant shall be determined by the identification of all sources of hazard and by assessing each hazard.

Potential sources of ignition shall be identified and an assessment made of the risk of exposure of acrylonitrile leaks.

Where the risk is unacceptable consideration shall be given to:

- a) eliminating the source of ignition, and
- b) protecting the source of ignition from the leak.

Each item of integral section of equipment containing acrylonitrile, shall be provided with means of isolation from the rest of the system and with suitable connections for venting, purging and washing after the contents have been removed.

Enclosed plant areas where release of acrylonitrile could result in the build-up of vapour concentration, should either be regularly monitored by patrols or be provided with automatic monitoring devices, placed at appropriate points and connected to an alarm system.

7.6 Personnel — *No person shall be employed on plant handling acrylonitrile unless he has received specific training and has been provided with detailed operating instructions.* If leaks or spillage occur, only correctly protected personnel should remain in the area.

8. WASTE DISPOSAL (SOLID, LIQUID OR GASEOUS)

8.1 Waste mixture containing acrylonitrile should not be allowed to enter drains or sewers where serious explosions may result. The following methods are recommended for disposal:

- a) Liquid — There should be adequate arrangement for collection of spills or leaks of acrylonitrile which should be destroyed by burning. There should be arrangement for water washing of floors/area. *Avoid putting acrylonitrile waste to municipal drains, sewers directly or to the earth or underground water.*
- b) Drum — Wash and steam, cut into pieces and destroy.
- c) Solid waste or rubbish — Burn.

8.2 Contaminated earth, sand or absorbent materials shall be collected and should be chemically treated over a period until they are safe for disposal. Alternatively, the contaminated materials may be incinerated.

Untreated acrylonitrile must not be allowed to enter open drains or sewers. Should this occur inadvertently, flush with copious quantities of water, *check for flammability and toxicity downstream*, and inform the appropriate authority.

9. FIRE PREVENTION

9.1 Electrical equipment that is installed in a plant area, shall be entirely suitable for the classified area concerned. For use in other than safe areas it should be certified or approved by the appropriate statutory or test authority for use under the particular conditions. Sparks from electrical equipment can become sources of ignition and consideration should be given to locating the electrical equipment associated with the plant outside that area. This will not be possible with items of equipment, such as

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motors, instruments and it may be necessary to protect the source of ignition from an acrylonitrile leak by using equipment constructed in accordance with suitable design concepts; additional requirements are necessary for the installation, earthing and maintenance of such equipment.

9.2 Although at normal pumping rates of 3 m/sec acrylonitrile should not generate electrostatic charges in pipelines, all items of plant handling acrylonitrile shall be earthed in an approved manner against static discharges. Structural steelwork shall be effectively earthed and plant equipment bonded to the structural steelwork. Naked flame should not be allowed and smoking should be strictly prohibited and *engines of vehicles should be stopped if within 15 m of transfer operations*. Oxidising agents, concentrated acids, alkalies, silver nitrate salt should not be present where acrylonitrile is handled.

9.3 Earthing connections shall be provided for tankers which should be earthed before connections are made to the transfer line.

10. HAZARD INFORMATION

10.1 Acrylonitrile vapours being heavier than air, tend to spread and flash back from ignition sources. Uninhibited acrylonitrile undergoes polymerization by its own volition which will result in fire, explosion and rupture of vessels. *It should never be kept uninhibited in storages*. Further, oxidising agents, concentrated acids, alkalies, solid silver nitrate, peroxides, chlorosulphonic acid, alcohols, mercaptans, aldehydes, ketones, amines, ammonia, bromine and 1, 2, 3, 4-tetrahydrocarbazole react violently with acrylonitrile resulting in fire and explosions, if safety precautions are not taken.

Acrylonitrile is a highly toxic compound. Vapours may cause irritation to the eyes. Liquid splash will cause serious inflammation in the eyes. Liquid in contact with skin will produce irritation. Prolonged contact with skin will produce dermatitis. It can penetrate through leather shoes. It may produce blistering after several hours of no apparent effect. Inhalation may produce nausea, vomiting, headache, sneezing, weakness and light-headedness. Low concentration of vapours inhaled over a long period may cause flushing of face, nausea, giddiness and jaundice. Exposure to high concentration may produce profound weakness, asphyxia and death. It resembles hydrocyanic acid mildly in toxicity.

Earlier TLV for acrylonitrile was estimated to be 20 ppm for acute toxicity. But recent studies on acrylonitrile toxicity on rats have substantiated that acrylonitrile is a potential carcinogenous compound. The results from experimental animal studies have been reinforced by the Dupont mortality study of workers exposed to acrylonitrile which says "The preliminary results of an epidemiological study being performed by

Dupont on a cohort of workers in their Candew S. C. acrylic fibre plant indicate statistically significant increase in the incidence of colon- and lung-cancers among employees exposed to acrylonitrile.

In the acrylic fibre manufacturing process, it is during the wet-spinning process, between the coagulation bath and the hot water stretch that potential employed exposure to acrylonitrile is greatest, since the residual that is unreacted acrylonitrile monomer which remains in the fibre is being driven off along with the solvent. However, in processes where the coagulation is done in strong acid (or oxidising agent) medium at sub-zero temperature, the acrylonitrile released from the coagulated gel fibre will be decomposed by the bath solution. Besides the stretching is also done above the glass transit temperature of the fibre at low pH and drying and thermosetting are also done at higher temperatures. In such processes there is no likelihood of the presence of acrylonitrile monomer in the fibre. Further acrylonitrile level for all finished acrylonitrile are usually below 20 ppm by mass and it gets removed during the processing of fibre in hot water medium at temperatures above the wet glass transition temperature (that is 80°C).

In view of the hazards mentioned above, Occupational Safety and Health Association has set 2 ppm Threshold Limit Value (TLV) for 8 hour period with a ceiling level of 10 ppm for 15 minutes period during 8 hour day.

10.2 Use of hazard warning symbols/labels in plant areas — strongly recommended.

10.3 Cautionary and warning notices in plant use strongly recommended, like:

SMOKING STRICTLY PROHIBITED
NO NAKED LIGHTS
AVOID SPILLAGES
SAFETY FIRST
AVOID MOUTH-TO-MOUTH RESUSCITATION.

10.4 Information of Labels

Name of material;
Danger — Vapour hazardous flammable;
Do not breathe vapour;
Do not get in eyes, on skin, on clothing;
Use with adequate ventilation;
Keep away from heat and open flame; and
Keep container closed.

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11. PERSONAL PROTECTIVE EQUIPMENT

11.1 Suggested Respiratory Protective Devices

Respiratory

- | | |
|---|--|
| a) Gas mask with organic vapour canister | Where concentration of acrylonitrile is less than 2 percent by volume, but sufficient air is available |
| b) Self-contaminated breathing or air line respirator | Where concentration is more than 2 percent by volume |

11.2 Suggested Non-respiratory Protective Devices

Non-respiratory

- | | |
|-------------------|---|
| a) Hand gloves | PVC, neoprene or butyl rubber |
| b) Apron | |
| c) Safety goggles | Toughened glass, zero power |
| d) Face shield | Full cover face shield |
| e) Over shoes | Neoprene or rubber or PVC over the normal shoes |

NOTE — No leather shoes and clothings should be worn, as acrylonitrile will penetrate through leather. Even rubber-wears get swollen. Rubber wears should be washed immediately with copious amount of water after use. *Persons wearing contact lenses should not work with acrylonitrile unless lenses are properly protected by wearing glass goggles.*

12. TRAINING EDUCATION

12.1 Preplacement Training in Regular Safety Procedures

12.1.1 Personnel — Persons handling or working on plant involving acrylonitrile shall have such training that they can be expected to carry out their job effectively and knowledgeably. Persons who handle acrylonitrile should be instructed carefully in the accepted method of handling and be appraised of the use of protective equipment for safe handling. The hazardous properties of acrylonitrile due to fire explosions, eye contacts, skin contacts, inhalation and ingestion should be stressed soundly during instructions so as to impart an indelible impression on the persons who handle acrylonitrile. *All workers should be familiar with the location of safety showers, alarm boxes, emergency ventilation systems, first aid boxes, fire extinguishers and hose lines, protective equipment, gas masks and artificial respiration methods.* They should be given training in the methods of operation of the equipment mentioned.

12.1.2 Instruction — This training should be supplemented by detailed instructions covering all scheduled operations in the commissioning,

running, shutdown and maintenance of the whole installation. These instructions should preserve the design intent and should include action in the event of possible malfunctions which may occur.

12.2 Preplacement Training in Emergency Procedures

12.2.1 Emergency Situations — In addition, adequate instructions shall be given for the handling of emergency situations. These include:

- a) detailed procedures for tackling foreseeable abnormalities; and
- b) aide-memoire of key points, backed by general training which will provide guidance for the corrective action in emergency or potential emergency situations which have not been dealt with as specific cases.

12.2.2 Modifications — As training should be given from the operating instructions, all drawings should be kept up to date to include modifications to plant or procedure.

12.3 Refresher Courses — Refresher training should be given, particularly when modifications to the plant have taken place, to ensure that all remain aware of their own and other people's responsibilities and of the actions to be taken in both normal and emergency situations.

13. HEALTH MONITORING

13.1 Pre-employment examination is required for persons who would be exposed to acrylonitrile. Persons who are subject to fainting spells, such as occur in various types of cardiovascular and nervous disorders should not be exposed to acrylonitrile vapours. Periodic health examination, including chest X-rays, test on the intestinal tract including fecal occult blood screening of skin, respiratory tract, heart, central nervous system and liver should be performed on all employees exposed to acrylonitrile.

13.2 Periodical examination could be done annually.

13.3 A periodical surveillance of the peripheral and the central nervous systems, respiratory system and gastro intestinal system may be done on all persons who are exposed to or being exposed to acrylonitrile continuously. Proper records should be maintained so that any abnormal variation could be studied and remedies suggested by the physician.

14. FIRST-AID

14.1 Actions in Emergency

14.1.1 Objective — In the proposed code for the design and operation of acrylonitrile plants it is intended to make a major release of acrylonitrile

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improbable. Nevertheless, it cannot be assumed that an incident will not occur which involves people both within and outside the works.

14.1.2 Local Emergency Services — The local emergency services (fire brigade, ambulance service, hospitals and police) should be informed in advance of the potential hazards of acrylonitrile and be given all information necessary so that they can deal with any situation that may arise.

14.1.3 Emergency Procedures — “ Emergency Procedures ” should be drawn up to defining the necessary action should a major incident occur. The procedures should be agreed with the local emergency services and periodic practice drills arranged with them to test the effectiveness of contingency plans.

14.1.4 Responsibility — It would be the responsibility of the local emergency services to warn the local population in case of an incident, in which warning action is necessary.

14.1.5 Provisions — Emergency procedures should provide for:

- a) Prompt recognition of incidents presenting risk to plant, personnel and/or the public at large.
- b) Immediate alert of the appropriate works emergency service and those serving the local areas.
- c) Monitoring down-wind of any large escape.
- d) Action to control the incident and mitigate the effects.
- e) Protect personnel within and outside the works.
- f) Make safe other plants in the affected area.
- g) Local availability of additional emergency equipment.

14.1.6 First Aid Kit — First aid kit containing the following items should be kept handy:

- a) 25 amyl nitrite pearls (ampoules),
- b) 2 sterile ampoules of sodium nitrite solution (10 ml of a 25 percent solution in each),
- c) 2 sterile ampoules of sodium thiosulphate solution (50 ml of 25 percent solution in each),
- d) One 10-cc and one 50-cc sterile glass syringe with sterile intravenous needles,
- e) One tourniquet,
- f) One stomach tube,
- g) 10 gauze pads and 1 small bottle of 10 percent alcohol, and
- h) Two 5-l bottles of 1 percent sodium thiosulphate solution.

14.1.7 Important First Aid Instructions

- a) *Never give anything by mouth to an unconscious person.* In all cases keep patient quiet and warm until a physician arrives.
- b) Carry patient to fresh air. Have him lie down. Remove contaminated clothing but keep patient warm. Start the following first aid treatment immediately and **CALL A PHYSICIAN**.
- c) If patient is conscious and breathing:
 - i) Break an amyl nitrite pearl in a cloth and hold lightly over the nose for not more than 15-20 seconds. Repeat every 5 minutes for 25 minutes if recovery is not forthcoming.
 - ii) If acrylonitrile product has been **SWALLOWED**, give patient large quantities of 1 percent sodium thiosulphate solution (or soapy water or mustard water) by mouth every 15 minutes until vomiting occurs.
- d) If patient has stopped breathing:

Give artificial respiration until breathing starts. Break an amyl nitrite pearl in a cloth and hold lightly over nose for not more than 20 seconds, repeating every 5 minutes for 25 minutes or until breathing starts.
- e) If patient is unconscious but breathing:

Break an amyl nitrite pearl in a cloth and hold lightly over nose for not more than 20 seconds, repeating every 5 minutes for 25 minutes if recovery is not forthcoming. Give oxygen from an inhalator.
- f) Other precautions in first aid treatment are:
 - i) The rescuer before entering in a contaminated area must wear respirator for his own supply of uncontaminated air or oxygen and should use other personal protective equipment, if necessary.
 - ii) If acrylonitrile has entered the eyes, irrigate immediately with large quantity of water for a minimum period of 15 minutes. *Contact eye specialist.* No oils or oily ointment should be instilled unless advised by physician.

14.2 Use of Eye Fountains and Showers — Safety showers (*see* IS : 10592-1982*) should be provided at appropriate locations. Any affected skin should be washed immediately, eyes flushed with water and medical attention obtained.

*Specification for industrial emergency showers, eye and face fountains and combination units.

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14.3 Important information for use by a physician rendering medical aid to an affected person may be given in the following proforma:

PROFORMA

This patient (Name) was exposed to acrylonitrile, through
gas vapours ☐ liquid contact ☐ at/about am/pm,
on (date)..... 19.....

Degree of exposure (put ✓ in the appropriate square)

☐

Slight

☐

Severe

This substance is highly dangerous and may cause:

- a) paralysis of the respiratory centre;
- b) rapid tissue asphyxia by interference with the normal absorption of oxygen from the blood;

The early warning symptoms are:

- a) general weakness and heaviness of the arms and legs;
- b) increased difficulty in breathing; and
- c) headache, dizziness, nausea and vomiting.

The signs of severe poisoning are:

- a) pallor,
- b) unconsciousness, and
- c) cessation of breathing.

Poisoning may result from inhalation of the gas produced by evaporation of the liquid or by absorption through the skin.

INTERNATIONAL SYSTEM OF UNITS (SI UNITS)

Base Units

<i>Quantity</i>	<i>Unit</i>	<i>Symbol</i>
Length	metre	m
Mass	kilogram	kg
Time	second	s
Electric current	ampere	A
Thermodynamic temperature	kelvin	K
Luminous intensity	candela	cd
Amount of substance	mole	mo

Supplementary Units

<i>Quantity</i>	<i>Unit</i>	<i>Symbol</i>
Plane angle	radian	rad
Solid angle	steradian	sr

Derived Units

<i>Quantity</i>	<i>Unit</i>	<i>Symbol</i>	<i>Definition</i>
Force	newton	N	1 N = 1 kg.m/s ²
Energy	joule	J	1 J = 1N.m
Power	watt	W	1 W = 1 J/s
Flux	weber	Wb	1Wb = 1 V.s
Flux density	tesla	T	1 T = 1 Wb/m ²
Frequency	hertz	Hz	1 Hz = 1 c/s (s ⁻¹)
Electric conductance	siemens	S	1 S = 1 A/V
Electromotive force	volt	V	1 V = 1 W/A
Pressure, stress	pascal	Pa	1 Pa = 1 N/m ²



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